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COMPARISON OF CONVENTIONAL AND PROGRAMED INSTRUCTION IN TEACHING AVIONICS FUNDAMENTALS

Alexander A. Longo
G. Douglas Mayo

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COMPARISON OF CONVENTIONAL AND PROGRAMED INSTRUCTION
IN TEACHING AVIONICS FUNDAMENTALS

by

Alexander A. Longo
G. Douglas Mayo

December 1965

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Submitted by

G. D. Mayo, Ph.D., Director, Branch Office, Memphis, Tennessee

Approved by

E. I. Jones, Ph.D., Director, Navy Training Research Laboratory
E. E. Dudek, Ph.D., Technical Director
G. W. Watson, Commander, USN
Officer in Charge

Distribution of this document is unlimited

U. S. Navy Training Research Laboratory
U. S. Naval Personnel Research Activity
San Diego, California 92152

ACKNOWLEDGEMENTS

In all studies conducted in a typical training situation, research personnel must receive substantial assistance from training personnel in order to carry out the design of the study. In the case of research pertaining to programmed instruction, this dependence upon other personnel is even greater than ordinarily is true. This results, in part, from the time and effort required to produce acceptable programmed material, a step which must be completed before a study of the type described herein can be conducted.

Therefore, the contribution of the Avionics Programed Instruction Team at the Naval Air Technical Training Center, Memphis, Tennessee is gratefully acknowledged. A special word of appreciation also is due to the instructional, testing, and supervisory personnel at the Avionics Fundamentals School, who contributed much time and effort to the implementation of the research design. Finally, the prompt and accurate processing of the data by Data Processing Department personnel at the Naval Air Station, Memphis, Tennessee is appreciated.

BRIEF

The study reported herein is one of a series which, considered as a whole, is designed to provide a general statement concerning the increase in training efficiency that may be expected from programmed instruction technology within the Naval Air Technical Training Command. Individual studies, involving different course content and training conditions, must be conducted before a general statement of this type can be made.

This report compares the relative performance of 200 trainees taking 26 hours of conventional instruction in electronics fundamentals with 200 trainees covering the same subject matter in 19 hours, using programmed instruction.

The subject matter consisted of electrical calculations, direct current circuits and direct current meters. These areas were programmed by an electronics programming team in the Naval Air Technical Training Command. The programmed material had a "built-in" time saving of 27% as compared with conventional instruction. The sample was divided into two groups equated on the basis of the students' performance in an earlier training course. The measures of performance used in the study consisted of two tests: a 50 item constructed response test and a 50 item multiple choice test.

The results of the study indicated that: (1) the basic electronics students learned a relatively large block of programmed material to about the same degree but in substantially less time than was required by conventional instruction; (2) the constructed response examination, prepared for programmed instruction purposes, exhibited satisfactory reliability; (3) the conventional and programmed instruction groups did not differ significantly with respect to variability in performance; (4) the "90/90 performance level" of programmed material decreased as a function of the amount of programmed material tested at a given time.

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COMPARISON OF CONVENTIONAL AND PROGRAMED INSTRUCTION IN TEACHING AVIONICS FUNDAMENTALS

A. The Problem and Its Background

Reducing training time without reducing the quality of the training product has become one of the more attractive approaches in recent years to improving training efficiency in the Naval Air Technical Training Command. Historically, relatively small gains have been made in the research area of training methods, with respect to improvement of student performance (DuBois and Manning, 1960). Recent research, however, in the field of programed instruction appears to hold promise of a "breakthrough" in training methods, with reduction in training time as a valuable dividend.

The Naval Air Technical Training Command has established an in-house capability to program those areas of technical training which appear best suited to this mode of instruction. A recent study on five programed booklets supported the hypothesis that learning at about the same level can be achieved by programed instruction in substantially less time than is required by conventional instruction (Mayo and Longo, 1966). In that study, 13 hours of conventional instruction on electrical physics were reduced to 9 hours of programed instruction with no loss in the quality of student performance. This represented a 31% time saving.

This is the second in a series of studies to provide information concerning the above hypothesis, as it applies to larger segments of programed material. This investigation examines 26 hours of conventional instruction on electrical calculations, direct current circuits, and direct current meters programed to 19 hours, for a time saving of 27%. The primary objective of the study is to provide information on the following question: Can students learn a fairly large sequence of programed material to about the same degree, but in a substantially shorter period of time, than is presently accomplished by conventional methods?

Other questions on which the investigation provides evidence follow:

- a. Does the constructed response type examination, used to evaluate the programed material, have adequate reliability?
- b. Is there a significant difference between the programed and conventional instruction groups in terms of variability on performance measures?
- c. To what extent is the performance level, established in the development of a single program, maintained in a larger sequence of programed material?

B. Development of Programed Material

1. Programed Instruction Material

The programed instruction materials on electrical calculations, direct current circuits, and direct current meters were developed by a programing team in the Naval Air Technical Training Center, Memphis, Tennessee. The programing team consisted of three chief petty officers and one civilian educational specialist, all technically competent in the electronics area. All members of the team had received formal training, and experience in instructional programing.

a. The programed instruction set. The programed material pertained to subject matter appearing in the second and third weeks of the Avionics Fundamentals School, Class A. It consisted of nine individual programs, called sets, which were designed to replace 26 hours of conventional instruction with 19 hours of programed instruction. The titles of these sets were as follows:

- | | |
|--------------------------------|-----------------|
| (1) Mechanical Calculations | (6) Ammeters |
| (2) Electrical Calculations | (7) Voltmeters |
| (3) Series Circuits | (8) Ohmmeters |
| (4) Parallel Circuits | (9) Multimeters |
| (5) Meter Movements and Scales | |

The usual steps in instructional programing were followed in the preparation of each programed set. This includes task analysis, statement of specific behavioral objectives or terminal behavior specifications, construction of criterion test items to measure each objective, actual program writing, and successive revisions of the program with samples of the target population until 90% of the students completing the program had achieved 90% of the objectives. This is referred to as the "90/90 performance level" or "90/90 criterion" in programed instruction. Several examples illustrating the behavioral objectives and programed material are contained in Appendix A.

b. The programed instruction package. The investigation included the nine programed sets indicated above. The nine sets were divided into three groups of closely related programed material called programed packages: Electrical Calculations, Direct Current Circuits and Direct Current Meters. These three packages were considered as a sequence of related programed material, called a block of programed instruction. This block of programed material included about 30% of the instructional hours in the second and third weeks of the 19 weeks Avionics Fundamentals course. Other activities such as laboratory work, reviews, and testing periods were not programed, but conducted in accordance with conventional procedures. Appendix B contains the master schedule indicating the order of presentation of the programed and conventional material for the two school weeks in question. The programed packages employed both linear and branching procedures, depending

upon which was considered most appropriate by the programming team for the material being presented.

C. Method

1. Subjects. The sample consisted of 400 students entering the Avionics Fundamentals School, Class A, at the Naval Air Technical Training Center, Memphis, Tennessee, during the second week of July 1965 through the first week of August 1965. Only non-rated Navy and Marine Corps students were included.

2. Design. The study utilized a matched group design. The matching variable was the Aviation Fundamentals (AFUN(P)) School final grade, which previous research had indicated to be rather well correlated with performance in the Avionics Fundamentals School. This test correlated between .39 and .50 with the performance measures obtained in the present study, as shown in Table 1. Nearly perfect matching, including identical means (79.61) and standard deviations (7.29), was achieved by assigning essentially unselected personnel to the two treatment groups, and delaying actual matching (pairing of individuals) until after the completion of the segment of the course in which the study was conducted.

The two pools of students from which the matching was accomplished consisted of all members of the two treatment groups or pools, except a small number who had to be eliminated for non-academic reasons. In addition, a small number from the two pools of students could not be matched and were eliminated from the sample. The matching, of course, was made completely on the basis of the matching variable and without knowledge of the students' performance in the segment of the Avionics Fundamentals School in which the experiment was conducted. It was accomplished manually by matching cards from the two groups, the cards containing only the score on the matching variable and the name and service number of the student.

As noted previously, the students were divided into two groups prior to convening in the Avionics Fundamentals School: (a) the conventional instruction group (control), and (b) the programmed instruction group (experimental). The students were assigned to these groups according to the class section to which they were assigned. Assignment to sections was accomplished alphabetically. Assignment of sections to the two treatment groups (pools) was accomplished as follows: section "A" of the first class was assigned to the programmed group, section "B" to the conventional group, section "C" to the programmed group, etc. The assignment of the sections in the three remaining classes to the two methods of instruction was also alternated with respect to the preceding class in counterbalanced fashion. The assignment of class sections to programmed and conventional instruction is shown in Appendix C.

3. Administration of Programed Material. The programed material was administered by regular classroom instructors who previously had received instruction in presenting programed material. Written instructions, pertaining to the implementation of the study, also were given to the instructors. A resume of these instructions is contained in Appendix D. No special instructions were given to the students, since they had used programed materials in earlier course work. A suggested reading time, based upon the time required for approximately 90% of the students in the program validation sample to complete the program, was indicated on the first page of each programed booklet.

When considering the amount of programed material in terms of the suggested reading time, only $13\frac{1}{2}$ hours of instruction are involved. However, the material had to be assigned to regular one hour class periods which increased the administration time of the programed material to 19 hours. When more of the course is programed it is likely that more of the potential time reduction will be realized through adaptation of the classroom schedules to the materials. Students who could not complete a set in the time allotted on a particular day were required to complete it on their own time prior to the next school day. Students completing the program in less than the time allotted were permitted to use the extra time in a constructive manner, e.g., work on homestudy assignments.

4. Criteria. In order to provide a reasonably adequate criterion measure on which to base the comparison of the programed and conventional types of instruction two different tests were employed: a constructed response test based on the programed material and a multiple choice test based on the conventional material. Both tests were administered to both groups at the end of the experimental training period, the third week of Avionics Fundamentals School. The programed instruction test contained a sample of 50 items directly related to the specific behavioral objectives of the programed sets included in the investigation. The conventional instruction test also contained 50 items, essentially all of the items used by the school to measure achievement on the conventional material that subsequently was programed.

D. Results and Interpretation

The intercorrelations among the measures involved in the study are shown in Table 1. As indicated in the previous section, the correlations between the matching variable, Aviation Fundamentals School final grade, and the other measures ranged between .39 and .50. The correlation between the two measures of performance was moderately high at .78 and .79 within the conventional and programed groups respectively.

TABLE 1

Intercorrelations Within Programed and
Conventional Instruction Groups
(N = 200 in Each Group)

	<u>Prog. Inst. Test</u>		<u>Conv. Inst. Test</u>	
	<u>Prog. Group</u>	<u>Conv. Group</u>	<u>Prog. Group</u>	<u>Conv. Group</u>
AFUN(P) Grade	.45	.48	.50	.39
Prog. Inst. Test	-	-	.79	.78
Conv. Inst. Test	.79	.78	-	-

Table 2 contains the reliability coefficients for both tests for both groups. These were computed by means of the Kuder-Richardson Formula 20. The correlations range from .84 to .90, which is interpreted as satisfactory reliability for the purpose for which the tests are being used.

TABLE 2

Kuder-Richardson Reliability Coefficients for the Programed
Instruction Constructed Response Test and for the Conventional Test

<u>Instructional Group</u>	<u>Test</u>	<u>KR-20</u>
Programed Group	Prog. Inst. Test ¹	.85
	Conv. Inst. Test ²	.84
Conventional Group	Prog. Inst. Test	.90
	Conv. Inst. Test	.84

¹Constructed response items

²Multiple choice items

A comparison of the programed group with the conventional group with respect to the programed instruction constructed response test and the conventional instruction test is shown in Table 3. The scores indicate the number of items answered correctly, out of 50, by the conventional group on the programed instruction test was 37.22 as compared with 38.50 answered correctly by the programed group. The mean number answered correctly, out of 50, on the conventional instruction examination by

the conventional group and programed instruction group was 40.40 and 39.32 respectively. In neither instance was the difference between the two groups statistically significant at the .05 level, as indicated by the t test of significance. These results should be considered, however, in relation to the instructional time required for the two methods. The programed group had taken only 19 hours of programed instruction, as compared with 26 hours of conventional instruction received by the conventional group on the same subject matter. This represents a time reduction of 27%.

TABLE 3

Means and Standard Deviations for
Conventional and Programed Instruction Groups
(N = 200 for both groups)

Test	Means		t ¹	Standard Deviations		t
	Conv. Group	Prog. Group		Conv. Group	Prog. Group	
AFUN(P) ²	79.61	79.61		7.29	7.29	
Prog. Inst.	37.22	38.50	1.95	7.55	7.05	1.01
Conv. Inst.	40.40	39.32	1.87	6.48	6.40	.17

¹t value of 1.97 is required for significance at .05 level

²Matching variable

Table 3 also indicates that the t tests for differences in variability on the two tests were not significant. This statistic was computed primarily to investigate the influence of programed instruction on the variability of student performance. However, the finding also assists in interpretation of the results on differences between the means wherein it is assumed that the groups are from a common population. It has been speculated that programed instruction tends to restrict the variability of group performance. The results do not support this speculation.

The fourth question investigated was concerned with the extent to which the 90/90 criterion achieved on a programed set or small unit, is curtailed in a larger unit of programed instruction. Table 4 contains data relating to this question. It appears that the high criterion level of 90/90, achieved on the programed sets individually, decreases as a function of the number of sets (or programed hours) tested at a given time. The score distribution on a given programed set tends to have high negative skewness since each set is technically developed to provide almost perfect mastery. As expected, however,

score distributions on several programmed sets combined, exhibit greater variability and are more nearly normal as compared to performance on the programmed sets considered singly.

TABLE 4
Performance Level of Programed Material by Amount
of Programed Instruction Tested at a Given Time

Unit of Material	Time	Performance Level Achieved
Programed Set	2 hrs	90/90 ¹
Programed Package	9 hrs (5 sets)	64/90 ²
Programed Block	19 hrs (9 sets)	22/90 ³

¹Read as follows: 90% of students achieved 90% of objectives, etc.

²Results obtained in previous investigation

³Results obtained in present investigation

E. Summary of Findings

The primary question considered in the study was whether students can learn a fairly large sequence of programed material to about the same degree, but in a substantially shorter period of time, than is presently accomplished by conventional methods. Three other questions relating to the nature of programed material also were investigated. Evidence pertaining to the four questions is as follows:

1. Reduction in Training Time. It was found that basic electronics students can learn a fairly large block of material by means of programed instruction to about the same level, but in substantially less time than by conventional methods of instruction. The conventional and programed instruction groups demonstrated essentially equivalent achievement on both the constructed response and conventional tests. By design, however, the programed instruction material included a 27% time reduction. These results agree with the findings of a previous study wherein 13 hours of conventional material (i.e. half as much as included in the present study) was reduced to 9 hours of programed material (a 31% time reduction) without loss in instructional quality. The results of the two studies suggest that the amount of programed material does not adversely affect the statement that students using programed instruction learn as well as those taught by conventional instruction, and in substantially less time. Further research, will be required to fully verify this statement, however.

2. Reliability of the Constructed Response Test. The constructed response type examination, designed to measure the accomplishment of the

objectives of the programed material, exhibited satisfactory reliability. The Kuder-Richardson 20 coefficients for this test, as given to the programed group and conventional group, were .85 and .90, respectively. This reliability coefficient, however, pertains to a fairly large sequence of programed material (i.e. 19 hours). The reliability of short constructed response tests such as those employed in the validation of programed sets (i.e. 2 to 3 hours of programed material) remains to be investigated. Other research is being conducted along this line.

3. Variability of Performance. The results did not show any significant difference between the programed and conventional groups in terms of variability of performance. It has been speculated that programed instruction will tend to make a group very homogeneous, since each program is designed to meet a 90/90 criterion, or almost complete mastery. In the previous study, which examined a sequence of five programs, a significant reduction in variability in the case of the programed instruction material was observed which lent support to this speculation. It is possible that when a larger sequence of programed material is examined, individual differences in learning and retention begin to be exhibited once again, resulting in greater group dispersion. Some of the statistical difficulties associated with the narrow range of scores obtained on a programed set may not be as serious with larger sequences of programed material.

4. Performance Level of Programed Material. Performance of a programed set at the 90/90 level was found to decrease as a function of the number of programed hours (or sets) tested at a given time, as expected. A lowering of the 90/90 performance level may be a natural result of individual differences in retention when a large sequence of programed material is involved.

F. Implications

1. The programed material examined in this study was demonstrated to be effective in comparison with conventional modes of instruction. The instructional program used in the study currently is in use in the electronics fundamentals curriculum. The extension of programed instruction techniques to other appropriate electronics training areas, of a similar type, appears to be indicated.

2. Before a general statement can be made concerning the extent of increase in training efficiency that may be expected from programed instruction within the Naval Air Technical Training Command, other studies involving different course content and training conditions must be completed.

REFERENCES

DuBois, P. H. and Manning, W. H. Methods of Research in Technical Training, St. Louis: Department of Psychology, Washington University, January 1960. Nonr. 816(02). (Technical Report No. 3, Revised Edition)

Mayo, G. D. and Longo, A. A. Training Time and Programed Instruction, Journal of Applied Psychology, 1966 (in press).

APPENDIX A

SPECIFIC BEHAVIORAL OBJECTIVES AND A SAMPLE PAGE FROM THREE PROGRAMS

(In all cases, the sample page pertains to the
first behavioral objective of each program)

ELECTRICAL CALCULATIONS

OBJECTIVES

SET 2A - WORK, POWER AND ENERGY (MECHANICAL)

1. The student will define potential energy.
2. The student will define kinetic energy.
3. The student will state the formula for work.
4. Given values of force and distance, the student will solve for work.
5. The student will define mechanical power.
6. The student will define mechanical horsepower.
7. Given work and time, the student will solve for power in terms of horsepower.

SUGGESTED READING TIME 50 MINUTES

8A

YOUR ANSWER: Potential energy.

Yes, this is true, but you missed half the picture. The pendulum possesses potential energy only as long as you are holding it to one side.

We have defined potential energy as stored energy, or energy of position. In the case of our pendulum, when you pull the pendulum bob to one side, you are storing potential energy by lifting the bob against the pull of gravity. As the bob swings downward and forward, the potential energy becomes kinetic. The kinetic energy released is sufficient to carry the bob upward again on the opposite side, thus storing up more potential energy.

Refer to figures 1 and 2 below.

Figure 1
Potential
or stored
energy.

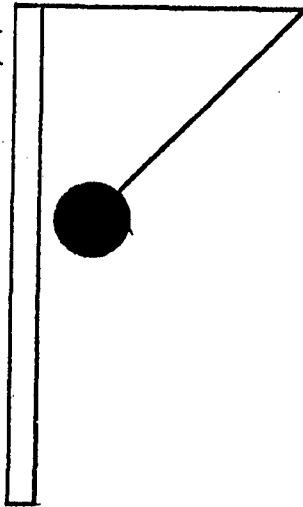
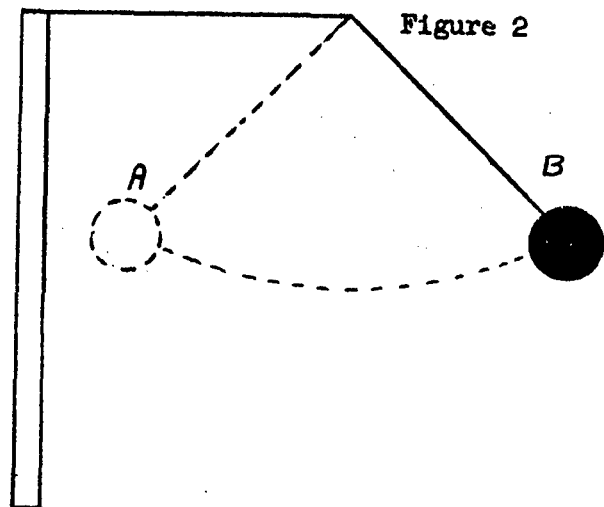


Figure 2



As the pendulum swings, the potential energy becomes kinetic energy, but at point "A" the kinetic energy is changed back to potential energy. As it swings back toward point "B", the potential energy again becomes kinetic energy.

Return to page 6A and select the more correct answer.

D.C. METERS

OBJECTIVES

SET 3 - VOLTMETERS

1. The student will write the definition of a voltmeter.
2. The student will write the definition of voltmeter sensitivity.
3. The student will write the formula used to solve for voltmeter sensitivity.
4. Given a circuit and several voltmeters, the student will select the voltmeter that will have the least "loading effect" on the circuit and write the reason for his selection.
5. The student will write the purpose of a "multiplier" used in a voltmeter.
6. Given a simple series circuit, containing a voltage source and three resistors labeled R_1 , R_2 and R_3 , the student will draw a voltmeter correctly connected to indicate the voltage drop across any one of the three resistors.
7. Given a drawing of a voltmeter with specified values of I_m and R_m , the student will solve the ohms/volt rating of the voltmeter.
8. Given a schematic of a multirange voltmeter, and given specified values of I_m and R_m , the student will solve for (1) the ohms/volt rating of the voltmeter, and (2) the value of the series resistors (R_s) required for each range.

SUGGESTED READING TIME 91 MINUTES

A voltmeter is a high-resistance device which is used to indicate potential difference, in volts, across a circuit or circuit component.

We say indicate (rather than measure) because, as you may well remember from your studies of meter movements and scales, all meters measure current. The meter scale is calibrated to convert the current reading directly to the unit we desire to read. In this lesson, we will be concerned with the volt.

A voltmeter is connected in parallel with the circuit, or circuit component, under test. See Figure 1.

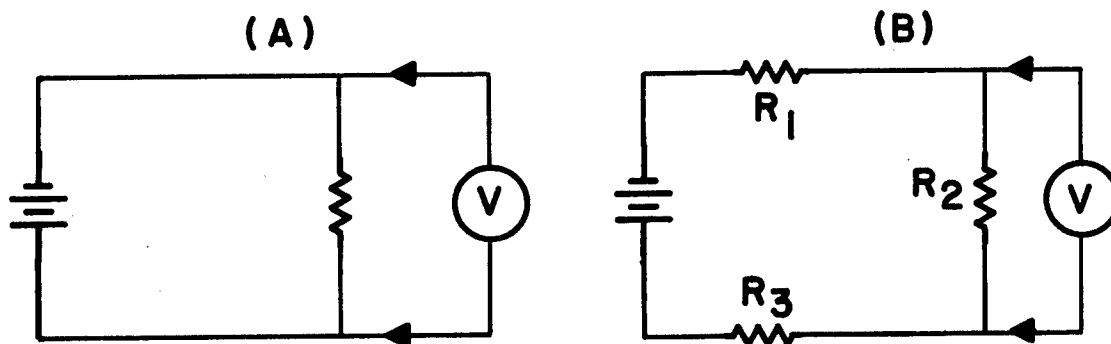


Figure 1.

In Figure 1A, the voltmeter indicates the entire circuit voltage. In Figure 1B, the voltmeter indicates only the voltage drop across R_2 .

Now, complete this statement.

A voltmeter _____.

measures current

page 3A

measures voltage

page 6A

D.C. METERS

OBJECTIVES

SET 4 - OHMMETERS

1. The student will write the definition of an ohmmeter.
2. The student will list the three major components of a basic ohmmeter.
3. The student will list the two types of ohmmeters.
4. The student will write the purpose of the current-limiting resistor (R_L) in an ohmmeter circuit.
5. The student will write the purpose of the "zero adjust" rheostat (R_A) in an ohmmeter circuit.
6. Given an ohmmeter circuit with selected values of E , R_M , I_M , and R_L , the student will solve for the value of R_A .
7. Given an ohmmeter circuit with selected values of E , R_M , I_M , R_L , and R_A , the student will solve for the value of the unknown resistor, R_X .
8. The student will list the four safety precautions to be observed when using an ohmmeter.

SUGGESTED READING TIME 60 MINUTES

<u>1A</u>	<p>1. An ohmmeter is an instrument designed to indicate electrical resistance.</p> <p>An instrument designed to indicate electrical resistance is called an _____.</p>
ohmmeter	<p>2. An ohmmeter is an instrument designed to indicate electrical _____.</p>
resistance	<p>3. An ohmmeter is an instrument designed to indicate _____.</p>
electrical resistance	<p>4. An ohmmeter is an instrument designed to _____ electrical resistance.</p>
indicate	<p>5. An ohmmeter is an instrument designed to _____.</p>
indicate electrical resistance	<p>6. Write the definition of an ohmmeter. _____</p> <p>_____</p> <p>_____</p> <p>_____</p>
Continue on next page.	

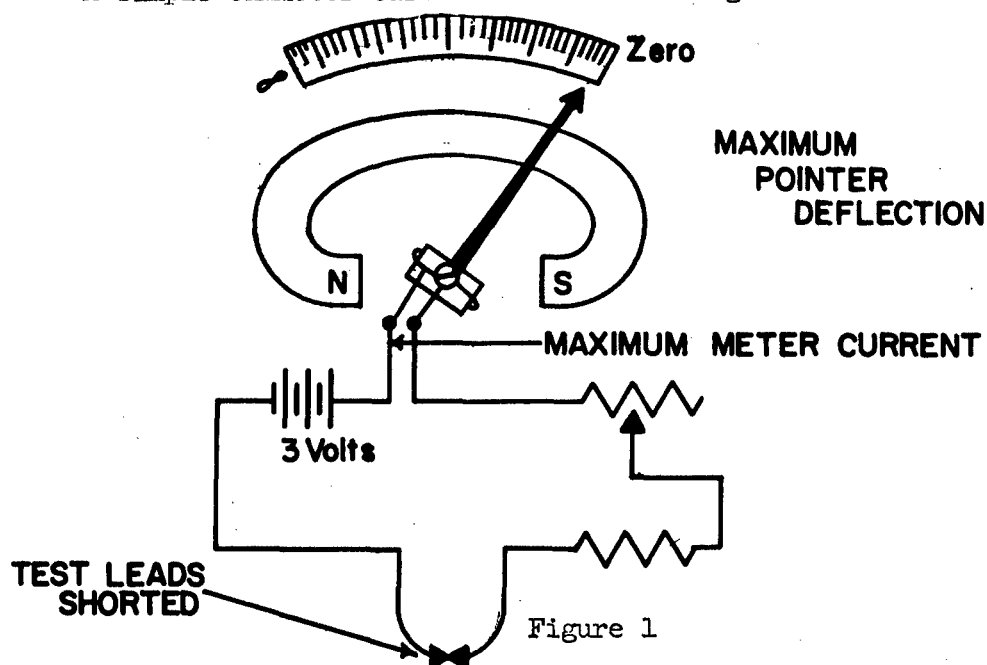
2A

ANSWER: An ohmmeter is an instrument designed to indicate electrical resistance.

An ohmmeter consists of a d.c. meter movement, which was discussed in an earlier lesson, with a few added features. The added features are:

1. a d.c. source of potential (usually a 3-volt battery).
2. one or more resistors (one of which is variable).

A simple ohmmeter circuit is shown in Figure 1.



The ohmmeter pointer deflection is controlled by the amount of battery current passing through the moving coil.

An ohmmeter consists of _____ major components.

Three

Page 6A

Two

Page 4A

APPENDIX B

MASTER SCHEDULE FOR PROGRAMED AND CONVENTIONAL GROUPS

SECOND WEEK		MASTER SCHEDULE (Programed Group)		July 1965
Day	Type	Hour	Subject	
Monday				
	Lab	41	Installation of Coded Resistors	
		42		
		43		
		44		
		45		
	Class	46	Conversion of Electrical Units	
		47		
		48		
Tuesday				
	Class	49	Conversion of Electrical Units (Drill)	
		50		
	Lab	51	Safety Wiring	
		52		
	Class	53	Moral Guidance	
* (P-11-2A)	Class	54	Work, Power, and Energy (Mechanical)	
* (P-11-2B)	Class	55	Work, Power, and Energy (Electrical)	
* (P-11-2B)	Class	56	Work, Power, and Energy	
Wednesday				
	Class	57	Conversion of Electrical Units (Drill)	
	Class	58	Coaxial Connectors	
	Lab	59	Coaxial Connectors	
		60		
* (P-111-1)	Class	61	Series Circuits	
*		62		
*		63		
*		64		
Thursday				
* (P-111-2)	Class	65	Parallel Circuits	
*		66		
*		67		
	Class	68	Batteries, Care and Safety	
		69	Organized Athletics	
		70		
		71		
	Class	71	Avionics Rating Familiarization	
		72		
Friday				
	Class	73	Series-Parallel Circuits	
		74		
		75		
	Class	76	Series-Parallel Circuits (Drill)	
	Class	77	Progress Test	
	Class	78	Magnetism	
	Class	79	Electro Magnetism	
		80		

*Programed classes

MASTER SCHEDULE (Conventional Group)				July 1965
SECOND WEEK				
Day	Type	Hour	Subject	
Monday				
	Lab	41	Installation of Coded Resistors	
		42		
		43		
		44		
		45		
	Class	46	Conversion of Electrical Units	
		47		
		48		
Tuesday				
	Class	49	Conversion of Electrical Units (Drill)	
		50		
	Lab	51	Safety Wiring	
		52		
	Class	53	Moral Guidance	
		54	Conversion of Electrical Units (Drill)	
	Class	55	Work, Power, and Energy	
		56		
Wednesday				
	Class	57	Work, Power, and Energy (Drill)	
	Class	58	Coaxial Connectors	
	Lab	59	Coaxial Connectors	
		60		
	Class	61	Series Circuits	
		62		
		63		
		64		
Thursday				
	Class	65	Series Circuits (Drill)	
		66		
	Class	67	Parallel Circuits	
		68		
	Class	69	Parallel Circuits (Drill)	
		70		
	Class	71	Batteries, Care and Safety	
	Class	72	Series-Parallel Circuits	
Friday				
	Class	73	Parallel Circuits (Drill)	
	Class	74	Series-Parallel Circuits	
		75		
	Class	76	Series-Parallel Circuits (Drill)	
	Class	77	Progress Test	
	Class	78	Magnetism	
	Class	79	Electromagnetism	
		80		

THIRD WEEK		MASTER SCHEDULE (Programed Group)		July 1965
Day	Type	Hour	Subject	
Monday				
	Class	81	Organized Athletics	
		82		
	Class	83	Combination Series-Parallel Circuits	
		84		
	Class	85	Combination Series-Parallel Circuits (Drill)	
		86		
		87		
		88		
Tuesday				
	Class	89	Combination Series-Parallel Circuits (Drill)	
	Class	90	Voltage Dividers	
		91		
	Class	92	Voltage Dividers (Drill)	
* (P-V-1)	Class	93	Meter Movements and Scales	
*		94		
* (P-V-2)	Class	95	D.C. Ammeters	
*		96		
Wednesday				
	Lab	97	Use of Ammeters	
		98		
* (P-V-3)	Class	99	D.C. Voltmeters	
*		100		
	Lab	101	Use of Voltmeters	
		102		
	Class	103	Organized Athletics	
* (P-V-4)	Class	104	Ohmmeters	
Thursday				
* (P-V-5)	Class	105	Multimeters	
*		106		
	Lab	107	Use of Multimeters	
		108		
		109		
		110		
COMPARATIVE	Class	111	Test - Crit. 50 Ques.	
STUDY		112		
Friday				
	Class	113	Review	
		114		
	Class	115	Test, Record	
		116		
	Lab	117	Performance Test	
		118		
COMPARATIVE	Class	119	Test - 50 Prog. Mat. (Conv. Test)	
STUDY		120		
*Programed classes				

*Programed classes

MASTER SCHEDULE (Conventional Group)				July 1965
THIRD WEEK	Day	Type	Hour	Subject
Monday				
		Class	81	Electrical Measurements
			82	
		Class	83	Combination Series Parallel
			84	
		Class	85	Combination Series Parallel (Drill)
			86	
			87	
			88	
Tuesday				
		Class	89	Voltage Dividers
			90	
		Class	91	Voltage Dividers (Drill)
		Class	92	Meter Movements and Scales
			93	
			94	
		Class	95	D.C. Ammeters
		Class	96	D.C. Ammeters (Drill)
Wednesday				
		Lab	97	Use of Ammeters
			98	
		Class	99	D.C. Voltmeters
		Class	100	D.C. Voltmeters (Drill)
		Lab	101	Use of Voltmeters and Ammeters
			102	
		Class	103	Ohmmeters
		Class	104	Ohmmeters (Drill)
Thursday				
		Class	105	Multimeters
		Class	106	Multimeters (Drill)
		Lab	107	Use of Multimeters
			108	
			109	
			110	
COMPARATIVE STUDY	Class		111	Test - Crit. 50 Ques.
			112	
Friday				
		Class	113	Review
			114	
		Class	115	Test, Record
			116	
		Lab	117	Performance Test
			118	
COMPARATIVE STUDY	Class		119	Test - 50 Prog. Mat. (Conv. Test)
			120	Test

APPENDIX C

ASSIGNMENT OF CLASS SECTIONS TO PROGRAMED* AND CONVENTIONAL* INSTRUCTION

CLASS	SECTIONS					
	A	B	C	D	E	F
I	P	C	P	C	P	C
II	C	P	C	P	C	P
III	P	C	P	C	P	C
IV	C	P	C	P	C	P

*P - Programed Instruction

*C - Conventional Instruction

APPENDIX D

RESUME OF INSTRUCTIONS TO INSTRUCTORS

A comparative study will be performed on four classes beginning 19 July 1965. These special instructions for these four classes are to control, as much as possible, the conditions existing, and the attitude of the students during this period so that the comparative study results will be as valid as possible.

1. The review material included in the programed booklet is to be ignored for the purposes of this study.
2. The regular homework will be assigned.
3. For maximum learning, all of the suggested reading time listed in the programed package should be used on the programed material.
4. Adhere to the new Master Schedule for weeks 2 and 3. The time indicated on the master schedule includes introduction and conclusion time when needed.
5. Individual student questions on any material (including programed material) are to be answered in the normal manner whenever they arise.
6. On scheduled reviews where a whole week or three weeks is reviewed to prepare for a test, the programed material will also be reviewed, but given its natural weight in the discussion.
7. Time set aside on the master schedule to review smaller units of material will not be used to review programed material.
8. Night school will be conducted in the normal manner with no changes.
9. Make no mention to students of a comparative study. The implementation is to be done in a manner that implies to the student that he is no different from the class before him or after him.
10. The general approach to these instructions is that all the time allotted to a package by the master schedule must be used as efficiently as possible, using the program as another training aid for the instructor. Time allocated to study and review of other material must be used for that purpose and not for programed material.

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This study is one of a series of investigations involving a variety of course content and training conditions where programed instruction will be compared with conventional classroom instruction to provide information about the general utility of programed instruction.

Here the performance of 200 trainees taking 26 hours of conventional instruction in electrical calculations, direct current circuits, and direct current meters is compared with the performance of 200 trainees taking 19 hours of programed instruction on the same content.

Results indicate: (1) The basic electronics students learned a relatively large block of programed material to about the same degree but in substantially less time than was required by conventional instruction; (2) the constructed response examination, prepared for programed instruction purposes, exhibited satisfactory reliability; (3) the conventional and programed instruction groups did not differ significantly with respect to variability in performance; (4) the "90/90 performance level" of programed material decreased as a function of the amount of programed material tested at a given time.

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